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ABSTRACT

This study explored the effects of a modified mastery learning strategy as well as locus of control and aptitude on achievement, attitudes, and on-task behavior of high school chemistry students (N=156). Mastery learning in this study was modified to limit diagnosis and remediation to two cycles. Three treatment groups were included: (1) contrast (no diagnostic/remediation procedures); (2) student-managed remediation (students selected their own remediation following diagnosis); and (3) teacher-managed remediation (teachers assigned remediation based on diagnostic test results). Results showed that the modified mastery learning strategy influenced on-task behavior and achievement indicating that high school chemistry teachers may successfully employ such a strategy to increase the on-task behavior and achievement of their students. Lack of significant differences between the two experimental groups suggested that assigned remediation may not be necessary to bring about achievement gains; simply having remediation available for students to use on their own may be sufficient. (Author/JN)

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THE EFFECTS OF A MODIFIED MASTERY LEARNING STRATEGY ON ACHIEVEMENT, ATTITUDES, AND ON-TASK BEHAVIOR OF HIGH SCHOOL CHEMISTRY STUDENTS

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Bloom (1968) proposed that the application of a teaching strategy which he termed mastery learning could enable most students to achieve at high levels. The mastery learning strategy consists essentially of frequent diagnosis and remediation of learning difficulties prior to summative testing (Block and Anderson, 1975). Remediation may be teacher-managed or student-managed (either the teacher or student is responsible for directing remediation). The mastery learning strategy has not gained wide acceptance perhaps because of the time inherent in cycling students through the diagnosis-remediation loop until complete mastery of instruction is accomplished. Another logistical problem is that of coordinating remediation exercises for a number of students. The use of mastery learning strategies may be viewed as more feasible by teachers if significant achievement gains can be made with a fixed number of diagnosis-remediation loops and if students can be given the responsibility for directing remediation.

In a student-directed mastery learning setting, the question arises whether there are some types of students who may be better able to direct their own remediation. Rotter (1966) has described a construct, locus of control, which may be useful in investigating the relationship between student characteristics and type of remediation strategy. This construct describes perception of control ranging from that of individuals perceiving themselves as being largely

in control of their behavior and subsequent rewards (internal locus of control) to individuals believing that fate, luck, or chance controls rewards (external locus of control). This characteristic may mediate the degree to which students can successfully manage self-directed remediation. An intuitive argument can be made that students who are more internally controlled would be better able to direct their own remediation than students who are more externally controlled.

Other recent research (cf. Rosenshine, 1977 and Lomax and Cooley, 1979) has documented a significant relationship between student on-task behavior and student achievement. On-task time is that time during which the learner is actively engaged in learning (Carroll, 1963). These studies suggest that student behavior may be a more significant factor in determining student outcomes than teacher behaviors or teaching strategies -- a point that has been argued by Medley (1977). Anderson (1976) reported a study in which mastery learning procedures were shown to increase on-task behavior of students.

Problem

This study explored the effects of a modified mastery learning strategy on the achievement, attitudes, and on-task behavior of high school chemistry students of differing aptitude and locus of control. Specifically the study addressed the following questions:

1. What effect does a modified mastery learning strategy have on (a) achievement, (b) attitudes, and (c) on-task behavior of high school chemistry students?

2. Do students of different locus of control orientation exhibit different (a) achievement, (b) attitudes, and (c) on-task behavior?

3. Do students of different academic aptitude exhibit different amounts of on-task behavior?

4. Will the application of a mastery learning strategy cause a change over time in on-task behavior of high school chemistry students?

Rationale

A number of studies in several subject areas and across grade levels from elementary to college have demonstrated the success of the mastery learning strategy. Swanson (1976) found the mastery learning strategy significantly superior when compared to a control strategy that did not utilize diagnostic and remediation exercises in high school chemistry classes. Goodson and Okey (1978), employing mastery learning techniques in a college level introductory physical science course, found students receiving formative testing along with remediation showed increased achievement when compared to students receiving no remediation. In a comprehensive review of mastery learning studies, Block and Burns (1977) concluded that mastery learning students achieved significantly higher 61% of the time over non-mastery students. Limited research on the question of student-directed versus teacher-directed remediation has shown inconsistent results. Goodson and Okey (1978) found that student-directed remediation and teacher-directed remediation groups both outscored a control group, but did not differ between themselves. Long (1978) found that a teacher-directed remediation group out-scored a student-directed remediation group of tenth grade biology students.

Mastery learning studies of student attitudes toward schooling do not show results as clearly as those of cognitive achievement. Wentling (1975) and Sanders and Yeany (1979) reported no significant differences in attitudes toward instruction as a result of mastery

learning strategies while Long (1978) reported that students in a student-directed remediation setting expressed significantly more positive attitudes toward instruction than students in either a teacher-directed or control group setting.

Studies which looked at how locus of control mediates student achievement have shown inconsistent results. Saunders and Yeany (1979) found internally-oriented middle school science students to achieve significantly higher than externally-oriented students in a study employing diagnosis-remediation strategies. Long (1978) and Yeany, et.al. (1979) reported no main effects due to locus of control orientation with college biology students when diagnosis-remediation techniques were used.

Procedures

Sample

The experiental sample consisted of 156 students from 9 classes enrolled in first-year chemistry in an urban/suburban high school in northwestern South Carolina. There were 84 males and 72 females in the sample; 130 were white and 26 black. The classes were relatively heterogeneous with respect to grade level, race, and aptitude. Each of the intact classes was randomly assigned to one of the three treatment groups.

Design

A 3 x 3 x 2 (treatment x aptitude x locus of control) fixed-factor design was used in the study. Students were blocked on three levels of academic aptitude (high, average, and low) based on the IQ measure from the Iowa Tests of Educational Development (Linquist & Feldt, 1966).

The Intellectual Achievement Responsibility (IAR) scale was used to assess and stratify on locus of control (McGhee and Crandall, 1968). Subjects were blocked on two levels of locus of control (internal and external).

Treatments

Instruction for all classes was characterized by a blend of lecture, question-answer sessions, laboratory work, demonstrations, and audio-visual materials. Course objectives were made available to all students. Unit quizzes, diagnostic quizzes, and remediation activities were developed cooperatively by the investigator and cooperating teachers. Diagnostic quizzes were based on logical subunits of each unit's objectives. The diagnostic quizzes were administered approximately every third day of instruction and typically took about five minutes to complete. Remediation exercises were keyed to objectives and were chosen from a variety of sources other than the original instructional materials.

These materials were used under three treatment conditions:

Treatment 1 (Contrast group). This group received the same instruction as the other two groups but without diagnostic quizzes and remediation activities.

Treatment 2 (Student-directed remediation). Subjects were given the same initial instruction as the contrast group, but with the added feature of diagnostic testing and remediation exercises. Students graded diagnostic tests themselves and selected remediation activities from a pool on their own initiative. All pertinent remediation activities were kept on file in a central, easily accessible location

in the classroom.

Treatment 3 (Teacher-directed remediation). This group received the same materials, instruction, and diagnostic tests as Treatment 2. However, the teacher randomly selected a remediation activity from the same pool available to Treatment 2. These activities were assigned as part of regular class instruction. The two experimental groups (Treatments 2 and 3) went through 2 cycles of diagnosis and remediation if necessary.

Dependent Measures

Quizzes based on the instructional objectives were given at the end of each of the three units. At the conclusion of the study a questionnaire was administered to determine attitudes of students toward science and science instruction. Throughout the study weekly on-task observation measures were made following procedures suggested by Anderson (1976). The on-task measure was a 2-point scale classifying students as either on or off task. The time each student was engaged in on-task behavior was estimated by taking the percent of the on-task codes relative to the total number of codes. The final criterion measure for each student was derived by taking the average of all on-task observations during the study. The reliability of the on-task measure was assessed by application of generalizability theory (Cardinet, et.al., 1976). Table 1 provides a summary of instruments used for dependent measures.

Insert Table 1 about here

Results

Group means and standard deviations for the achievement tests, the attitude questionnaire and the on-task observation measure are presented in Table II. Analysis of variance procedures with treatment, (T) aptitude, (APT) and locus of control (LOC) as main effects variables were used to determine the probability of real differences among the means. Probability levels of *F* - ratios are reported rather than adopting an *a apriori* α level.

Insert Table II about here

Preliminary analysis of the data indicated no significant three-way interactions so the final analysis was run specifying only two-way interactions. The computed *F* - ratios with their associated probability values are presented in Table III.

Insert Table III about here

On all the achievement measures, the main effect due to treatment was significant (see Table III). *Post hoc* analyses were carried out to determine which groups were achieving better than others. Orthogonal contrasts and Dunnett-*t* tests were used for these comparisons. These analyses indicated that on all achievement tests both the teacher-managed and student-managed mastery learning groups significantly outscored the contrast group. Only on the first achievement test was there a significant difference between the two mastery learning groups. In this case, the teacher-managed group scored significantly higher

than the student-managed group.

Analyses for main effects due to treatment indicated no significant differences in attitude toward science and science instruction (see Table III). On the on-task measure the main effect due to the treatment was significant ($F = 21.56$, $p = .0001$). Post hoc analyses indicated that the average on-task behavior of each of the mastery learning groups was significantly higher than that of the contrast groups, but were not significantly different from each other.

Analyses of main effects due to locus of control indicated no significant differences among groups on any of the criterion measures except attitude toward science instruction (see Table III). However, this difference was confounded by a significant disordinal treatment by locus of control interaction. Post hoc analysis of this interaction indicated that internals in the student-managed mastery learning group indicated a significantly higher positive attitude toward science instruction than did externals.

A trend analysis (Keppel, 1973) was carried out on the on-task measures to determine if there was a significant change in on-task behavior over time. The analysis indicated there was a significant linear trend ($F = 12.86$, $p < .001$) in on-task behavior. Figure 1 shows that, over time, the two mastery learning groups increased on-task behavior while the contrast group descreased on-task behavior.

Insert Figure 1 about here

The main effect due to aptitude on on-task behavior was significant (see Table I). Post hoc analysis using the Newman-Keuls multiple

comparison procedures indicated that the average on-task behavior of the low aptitude group was significantly higher than that of the average aptitude group.

Conclusions

Across the three achievement measures, the mastery learning groups were consistently favored; significant achievement gains were made with only two cycles of diagnosis and remediation. Yet an inconsistency in the performance of the two mastery learning groups were evident. The teacher-manged group achieved significantly higher than the student-managed group on the first achievement test; on the second and third achievement measures, no significant differences were found between the two mastery learning groups.

A possible explanation for the inconsistency in the effects of treatment on the two mastery learning groups may be that without direct teacher guidance, the students in the student-managed group were slower to realize the benefits that could accrue from the system. Once the benefits from the system were apparent, then the students might have been more attentive to the diagnostic tests and remediation exercises, and hence achieved at a level comparable to the teacher-directed mastery learning groups.

These results do not support the hypothesis that the mastery learning strategy could result in more positive attitudes paralleling higher achievement gains. STudents who elect to take high school chemistry probably have rather positive attitudes toward science and science instruction to begin with; increased achievement by itself may be insufficient to make such positive attitudes even more positive. The fact

that the attitudes of the two mastery learning groups did not change is of interest. The use of formative quizzes and remediation exercises could possibly be viewed by the student as just additional work and thus tend to lower attitudes

Both variations of the mastery learning strategy had a positive effect on on-task behavior of the students when compared to the contrast group, but no differences in on-task behavior were found between the two mastery learning strategies. In view of the significant relationship between on-task behavior and achievement noted by other researchers (cf. Rosenshine, 1977; Lomax & Cooley, 1979), this finding of increased on-task behavior is noteworthy.

Although a logical argument can be made for differential performance by internally and externally controlled students, this study largely failed to find such differences. These findings were consistent with those by Saunders and Yeany (1979).

In the case of attitude toward science instruction, a significant interaction of instructional strategy and locus of control appeared in the student-managed treatment group. Internals in this group showed more positive attitudes toward instruction than internals in either of the other treatment groups; externals had a less positive attitude toward instruction than externals in either of the other treatment groups. This finding is in accord with Daniels and Stevens (1976) and Parent, Forward, Cantor, and Mohling (1975). Internals would tend to prefer the situation of the student-managed group; they would be on their own to manage remediation. Externals would likely not prefer the situation of the student-managed group; they would prefer the teacher-managed group where instructional decisions were made by the teacher.

This study offers little support for Bloom's (1968) hypothesis that a mastery learning strategy can decrease differences in achievement among aptitude levels, as evidenced by the significant main effect due to aptitude and by the lack of any significant treatment group by aptitude interactions. Possibly this failure to support Bloom's hypothesis is due to the modifications of mastery learning employed in this study; two cycles of diagnosis and remediation may not be sufficient to reduce the differences in achievement among aptitude groups.

The finding that the low aptitude group spent the largest percentage of time on task is interesting. This finding may possibly be attributable to the context of the study--first year chemistry. For a low aptitude student to elect chemistry is a significant step in itself. Such students are probably highly motivated to pay more attention. Among high school students, chemistry ususally has the reputation of being a difficult course. Therefore, if low aptitude students elect chemistry, they more be more likely to pay attention.

The application of a modified mastery learning strategy in this study has resulted in an increase in achievement of high school chemistry students. The diagnostic testing with feedback and the increased on-task behavior may be operating jointly to bring about the gains in achievement. Additional research is needed to determine the relative contribution of diagnosis with feedback and on-task behavior to the achievement gains.

Implications

This study offers some empirical evidence to the high school chemistry teacher that instructional strategies can significantly increase

achievement. The modification of the mastery learning strategy employed in this study did increase achievement when compared to a non-mastery group.

High school chemistry teachers may be more willing to spend time constructing formative tests and using remediation activities with the knowledge that only two cycles of diagnosis-remediation can increase student achievement. This modified use of mastery learning may well be more appealing to high school chemistry teachers. In fact, the results of this study suggests that the assignment of remediation activities may not be necessary to bring about gains in achievement. Simply having the remediation activities available may be sufficient to increase achievement.

A meta-analysis of diagnostic-prescriptive studies by Yeany and Miller (1980) suggests that remediation activities may not even be necessary to increase achievement. They found that there was only a slight increase in the effect size across studies using diagnosis and remediation as compared to studies using only diagnosis with knowledge of results of the diagnosis and no remeidation. Perhaps the diagnostic tests serve to focus the attention of the students on the specific objectives to be assessed on the summative test and provide objective-specific practice sufficiently well to bring about the achievement gains. This finding bears further study.

This study failed to establish a relationship between locus of control and student outcomes. But the finding of a significant interaction between locus of control and instructional strategy on the attitude of students toward science instruction provides evidence to suggest that students of differing locus of control do perceive the

instructional setting differently. Knowledge of locus of control orientation of students may make the teacher more sensitive to students who need more direction.

The fact that this study showed a clear relationship between on-task behavior and instructional strategy suggests that teachers may increase on-task behavior by employing a modified mastery learning strategy. This study did not explore specific components of the mastery learning strategy that might be responsible for the increased on-task behavior. Implementation of a mastery learning strategy requires coordination of several different activities--diagnostic testing, feedback, and use of remediation activities. Before any of these are used in the classroom there must be planning and preparation of the materials. All these activities on the part of the teacher are management-related activities. Other studies have shown a positive relationship between classroom management and on-task behavior (cf. Anderson, Scott, Evertson, & Emmer, 1979). Perhaps the use of a mastery learning strategy enhances the management of the classroom which, in turn, leads to increased on-task behavior.

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Table I

Information on Instruments used in Study

Instrument	Number/Type of Items	Reliability Estimate
Unit 1 Achievement	35 items, multiple choice	.75[a]
Unit 2 Achievement	40 items, multiple choice	.74[a]
Unit 3 Achievement	18 items, multiple choice	.60[a]
Attitude toward Science	10 items, Likert scale	.79[a]
Attitude toward Science Instruction	10 items, Likert scale	.73[a]
On-Task Measure	classroom observations	.91[b]

[a]Cronbach's α
[b]generalizability coefficient: ρ^2

Table II

Means and Standard Deviations of Dependent Measures Across Treatment Levels

Dependent Measure	Treatment 1		Treatment 2		Treatment 3	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Unit 1 Achievement[a]	23.13	4.46	26.27	4.42	27.28	4.22
Unit 2 Achievement[b]	28.46	4.63	31.19	4.37	32.18	4.07
Unit 3 Achievement[c]	13.61	2.37	14.60	2.42	14.20	2.28
Attitude toward Science[d]	36.20	6.56	37.41	5.00	38.58	6.05
Attitude toward Science Instruction[d]	33.80	4.28	34.69	7.19	34.54	4.00
On-Task Behavior[e]	75.24	13.63	87.22	8.22	86.65	8.35

[a]Maximum possible score = 35
[b]Maximum possible score = 40
[c]Maximum possible score = 18
[d]Maximum possible score = 50
[e]Maximum possible score = 100

Table III

Analysis of Variance Results for all Dependent Measures

Measure	Treatment (T)		Aptitude (A)		Locus of Control (L)		T X A		T X L		A X L	
	F	p	F	p	F	p	F	p	F	p	F	p
Unit 1 Achievement	15.83*	.0001	5.32*	.006	.18	.67	.21	.93	.30	.74	2.08	.13
Unit 2 Achievement	9.39*	.0001	4.67*	.001	.03	.86	.72	.58	1.40	.25	1.68	.19
Unit 3 Achievement	2.49*	.09	3.00*	.05	1.07	.30	.52	.72	.05	.95	.96	.38
Attitude toward Science	1.89	.15	.28	.75	.41	.52	.11	.98	.74	.48	.12	.89
Attitude toward Science Instruction	.30	.74	1.99	.14	3.91*	.05	.40	.81	2.57*	.08	.90	.41
On-Task Behavior	21.56*	.0001	2.23*	.11	.48	.49	.27	.89	.07	.93	.09	.91

* judged to be significant

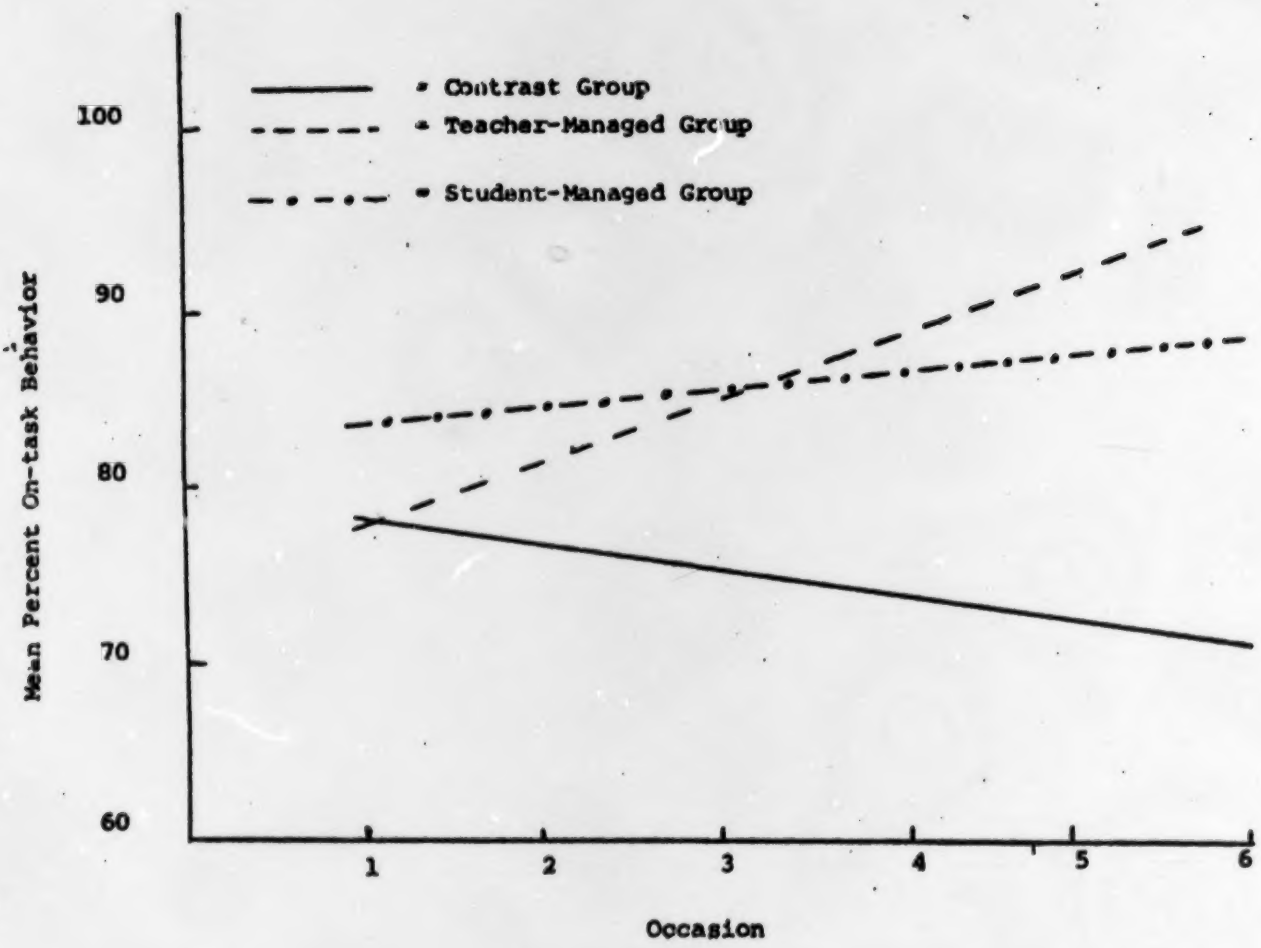

Figure 1. Average on-task behavior over time of the three treatment groups